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ABSTRACT

Conservation performance during childhood to portions of the life span beyond adolescence is examined, with existing data replicated on subjects ranging from the preschool to middle-childhood years. Age differences in performance are studied for the typical Piagetian paired-stimulus equivalence conservation of number, substance, weight, and volume tasks in subjects ranging in age from 6 to 82 years. Results indicate that the performance apex for conservation ability attained after childhood may not be as stable an acquisition as Piaget's theory implies. Rather, a regression with age to less complex modes of responding is noted, at least for the more complex tasks in the battery. The ability to conserve number, hypothesized to be the earliest appearing and therefore the most simple concept, remained stable even in the oldest subjects. The concepts of intermediate difficulty (substance and weight conservation) were present in only about half the oldest group. The formal operation of volume conservation, regarded as the latest developing and most complex acquisition had virtually disappeared from the response repertoire of the oldest subjects. Further research with large numbers of older subjects is needed. (LH)

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THE STATUS OF NUMBER AND QUANTITY CONSERVATION CONCEPTS ACROSS THE LIFE-SPAN[1]

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The present research represents an attempt to extend the rapidly growing collection of information on conservation performance during childhood to portions of the life-span beyond adolescence and to replicate the currently existing data on subjects ranging from the preschool to middle-childhood years.

Little theoretical or empirical attention has been focused on the quality of thought beyond adolescence. Piaget and Inhelder (1969) imply that such investigations seem unwarranted because

> . . . after the age of 11 or 12, nascent formal thought restructures the concrete operations by subordinating them to new structures whose development will continue throughout adolescence and all of later life (Piaget & Inhelder, 1969, pp. 152-153).

Flavell (1970) also does not regard the adult years as a time of any momentous cognitive change. Rather, those cognitive increments occurring between birth and adolescence are viewed as momentous, directional, uniform, and irreversible.

The present position (Hooper, Fitzgerald, & Papalia, 1971) differs markedly from that of Piaget and Inhelder (1969) and Flavell (1970). Hooper et al. (1971), noting conceptual and methodological similarities between logical operations tasks and fluid intelligence measures, predicted similar growth curves for the two. Both fluid intellectual abilities and logical operations task performance, because of their reliance on neural integrity,

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were viewed as increasing through childhood and potentially subject to qualitative regression and disorganization with age.

Several previous studies have assessed performance on traditional Piagetian measures in normal populations of old people (e.g., Kominski & Coppinger, 1968; Papalia, Salverson, & True, 1972; Sanders, Laurendeau, & Bergeron, 1966; Storck, Looft, & Hooper, 1972) and on aged clinical samples (e.g., Ajuriaguerra & Angelgues, 1960; Ajuriaguerra, Boehme, Richard, Sinclair, & Tissot, 1967; Ajuriaguerra & Hacean, 1960; Ajuriaguerra, Kluser, Velghe, & Tissot, 1965; Ajuriaguerra, Muller, & Tissot, 1964; Ajuriaguerra, Rey-Bellet-Muller, & Tissot, 1964; Ajuriaguerra, Richard, Rodriguez, & Tissot, 1966; Sinclair-de-Zwart, Ajuriaguerra, Boehme, & Tissot, 1966). These studies consistently reported the disintegration of various logical operations among aged persons.

The present study is an investigation of age differences in performance on the typical Piagetian paired-stimulus equivalence conservation of number, substance, weight, and volume tasks in subjects ranging in age from 6 to 82 years. It was hypothesized that (1) conservation ability would reach a peak performance level during late adolescence, (2) the ability to conserve would be lower in the old age group than in the group where performance proficiency reaches a peak level, (3) this decrement would proceed from the most complex to the most simple concepts. In Piagetian terms, formal operations (i.e., volume conservation) would be predicted to decline prior to concrete operations (i.e., number, substance, and weight conservation).

METHOD

Subjects. A sample of 96 Ss of middle class socio-economic status was

drawn from elementary schools, West Virginia University, the working population, a senior citizen's center, and a residential apartment for the elderly in Monongalia County, West Virginia. This group was composed of eight males and eight females from the age intervals six to seven years ($\bar{X}$ = 6 years 8 months; SD = 3.65 months), 11 to 13 years ($\bar{X}$ = 11 years 10 months; SD = 6.37 months), 18 to 19 years ($\bar{X}$ = 18 years 6 months; SD = 3.57 months), 30 to 54 years ($\bar{X}$ = 43 years 7 months; SD = 8.43 years), 55 to 64 years ($\bar{X}$ = 60 years 0 months; SD = 3.35 years), and over 65 years of age ($\bar{X}$ = 74 years 9 months; SD = 4.97 years).

Subjects in the three youngest groups attended first, sixth, and college freshman years of school, respectively. The elementary school children were randomly chosen from average-ability classrooms. The college freshmen were enrolled in an introductory psychology course, but were unfamiliar with the theory and testing methods used in this study. Subjects in the three older age ranges were active, healthy, apparently normal older people who participated in some type of community activity (e.g., work, senior citizen's center). Subjects who lacked good health or were under custodial care were not approached for testing. Mean educational attainment for the three oldest groups was 14.4 years (SD = 3.2 years), 14.3 years (SD = 3.4 years), and 11.6 years (SD = 3.2 years), respectively.

Procedure. One female experimenter individually administered a battery of standard Piagetian paired-stimulus equivalence conservation of number and quantity (i.e., substance, weight, and volume) tasks (adapted from Rothenberg, 1969, Elkind, 1961a, 1961b, 1962) to each subject in one of four counterbalanced presentation orders. The stimulus materials used

were poker chips for the number conservation task and clay for the quantity conservation battery. Three trials and a trial-and-check (in which a deliberate inequality must be judged) were given to assess each conservation concept. Subject and experimenter worked together to perform the required stimulus manipulations. Total test time was 15 minutes per subject.

Subjects were designated as conservers in a given content area if they passed and adequately justified at least two trials and a trial-and-check. Justifications were designated as either inadequate, i.e., rationale based upon the immediate perceptual features of the task setting or irrelevant statements, or adequate, i.e., statements indicating understanding of logical operations principles (adapted from Papalia & Hooper, 1971). In a second scoring condition, subjects were designated as conservers or non-conservers solely on the basis of their objective response (i.e., "same", "more") alone. As in the justification condition, subjects who passed two out of three of the conservation trials in a particular content area and the trial-and-check were given a pass designation for that concept.

RESULTS

Initial Considerations

No effect on performance could be attributed to order of presentation, sex differences, scoring criteria used, and educational level of the respondents in the three oldest groups. Consequently, all further analyses for each age group were performed on the combined male-female justification data across all orders of presentation.

Concerning sex of subject, there was a tendency for males in the three youngest groups to surpass their female counterparts, although their superiority never attained significance. Female subjects in the three oldest groups, on the contrary, tended to surpass their male peers. Correlations computed between performance on each task and educational attainment were of a low, nonsignificant magnitude. As would be expected for formal operations, volume conservation performance was more highly correlated with education than were the concrete operations of number, substance, and weight conservation.

Primary Considerations

Number conservation was the ability which held up with age. It was passed by 75% of the six- to seven-year-olds. All subjects in the remaining age groups conserved number.

More variability in quantity task performance (i.e., substance, weight, and volume) than in number conservation was evident. Substance conservation was passed by 56% of the six- to seven-year-olds, 68.7% of the 11- to 12-year-olds, 100% of the 18- to 19-year-olds, 87.5% of the 30- to 54-year-olds, 100% of the 55- to 64-year-olds, and 62.5% of the sample over 65 years of age. Successful performance on the weight conservation task was attained by 37.5% of the six- to seven-year-olds, 50% of the 11- to 13-year-olds, 100% of the 18- to 19-year-olds, 81.5% of the 30- to 54-year-olds, 93.7% of the 55- to 64-year-olds, and 50% of the sample over 65 years of age. Correct responses on the volume conservation problem were given by 6.25% of the six- to seven-year-olds, 12.5% of the 11- to 13-year-olds, 50% of the

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18- to 19-year-olds, 37.5% of the 30- to 54-year-olds, 75% of the 55- to 64-year-olds, and 6.25% of the sample over 65 years of age.

An analysis of the pass-fail patterns for the various groups indicates a large degree of uniformity in the order of task acquisition and decline. Only three subjects from this sample of 96 exhibited pass-fail performance patterns which deviated from the theoretical predictions of Piaget and Inhelder (e.g., 1941). The tasks were acquired in the predicted order of number, substance, weight, and volume and disappeared in the reverse of this order. These results are in accord with implications of a stage theory (Pinard & Laurendeau, 1969) in which success on a later task presupposes the ability to perform correctly on the earlier appearing tasks.

DISCUSSION

According to the first two hypotheses, conservation performance was predicted to increase through childhood, reach a peak performance level in the college age subjects, and then decline at some later point. Confirmation of these hypotheses depended upon the particular conservation content area under consideration. The highest overall mean performance level (based upon a possible score of zero to four) was attained not by the college age group, but by the subjects in the 55- to 64-year-old age range ($\bar{X}$ = 3.48 versus 3.69, respectively). Subjects in the oldest group attained an overall mean score of 2.41 which was considerably lower than those reported for the college age and middle age adult groups.

Analysis of scores for the specific content areas indicated differences in the age of peak performance dependent upon the particular content area under consideration. Although only 75% of the six- to seven-year-old subjects conserved number, this ability reached the 100% proficiency level in the 11- to 13-year-old group; perfect number conservation performance was maintained by all members of the remaining older age groups. More notable age differences were reported on the quantity tasks. Subjects in the six- to seven-year-old, 11- to 13-, and over 65-year-old groups performed less well than members of the 18- to 19-, 30- to 54-, and 55- to 64-year-old samples on substance, weight, and volume conservation tasks.

The third hypothesis was confirmed in that the decline in cognitive ability proceeded from the complex to simple (i.e., from volume, to weight, to substance, to number). It is, of course, implicit that the older subjects at one time possessed the abilities under consideration. However, only a longitudinal analysis would indicate whether these concepts were, in fact, at one time present and could thus conclusively be said to "disappear" with age.

Relationship to other empirical data. The age norms reported in the present research deviate slightly from those found by other authors. Number conservation is generally attained by age six, substance conservation by ages seven-eight, weight conservation by age nine, and volume conservation by ages eleven-twelve (e.g., Almy, Chittenden, & Miller, 1966; Churchill, 1958; Dodwell, 1960, 1961; Elkind, 1961a, b, c, 1962; Inhelder, 1944; Lovell & Ogilvie, 1960, 1961; Piaget & Inhelder, 1941; Smedslund,

1961; Uzgiris, 1964; Wohlwill, 1960). The horizontal décalage for quantity concepts (i.e., mass, weight, volume) has consistently been noted in the literature (e.g., Elkind, 1961a, b, 1962; Inhelder, 1944; Lovell & Ogilvie, 1960, 1961; Piaget & Inhelder, 1941, 1947; Smedslund, 1961; Uzgiris, 1964).

In the present study the subjects in the six- to seven-year-old group performed according to theoretical and empirical expectations. Number conservation was attained by 75% of the subjects in this group and slightly over half of these subjects conserved substance. Weight and volume conservation, although passed by some subjects, was not attained by the majority of the members of the youngest age group. Those in the 11- to 13-year-old group performed somewhat below expectation on all but the number task. Five subjects failed substance conservation, an ability which would be predicted to be attained by all subjects in this age range. In addition, only half of the subjects passed weight conservation and two subjects conserved volume. Both of these abilities should, theoretically, have been achieved by early adolescence. However, failure to conserve volume in this age group has also been noted by Elkind (1961b, 1962) and Uzgiris (1964). It is suggested that these subjects may show such poor performance on these tasks because of the general cognitive reorganization occurring as the early adolescent enters the formal operations stage of thought. Subjects in transitional periods often show inconsistent performance patterns on logical thought measures. In addition, the present volume task was more abstract than that used by several authors reporting conservation at ages 11-12 (e.g., Lovell & Ogilvie,

1961).

Subjects in the 18- to 19-year-old group performed as theorized on all tasks but volume conservation. Only half of the members of this group passed this task on which total success was theoretically anticipated. However, failure of high school and college age subjects on volume conservation problems has been noted in other research (e.g., Elkind, 1961a, 1962). In addition, the peak volume conservation level was not reached until beyond adolescence (i.e., in the 55-64 year old group; this ability should, theoretically, have been intact in the early adolescent subjects.

There are no studies available which provide information about number and quantity conservation tasks in normal adult and old age subjects. However, two studies investigated conservation of space in these age groups. Sanders et al., (1966) and Kominski and Coppinger (1968) noted age differences in performance on the Conservation of Surfaces Test devised by Piaget. In both of these studies, conservation ability appeared intact in adult subjects but a developmental trend more primitive levels of responding with advanced age was noted. Based upon the present results, a similar conclusion can be drawn for quantity, but not for number concepts.

The lower performance levels of older subjects on intelligence measures has frequently been noted in the literature. Although abilities which are based upon stored information (i.e., crystallized abilities) hold up well with age active problem-solving behavior requiring immediate solution of novel problems (i.e., fluid abilities) has consistently been shown to be impaired during the normal aging process. The abilities tapped by Piagetian measures are thought to overlap conceptually and operationally those abilities which fluid measures assess (Hooper, Fitzgerald, & Papalia, 1971).

Consequently, the relatively low performance of the members of the oldest age group is congruent with empirical findings as well as certain theoretical speculations.

SUMMARY AND CONCLUSIONS

Results of the present study indicate that the performance apex for conservation ability attained after childhood may not be as stable an acquisition as Piaget's theory implies (Piaget & Inhelder, 1969). Rather, a regression with age to less complex modes of responding has been noted, at least for the more comples tasks in the battery. The ability to conserve number, hypothesized to be the earliest appearing and therefore the most simple concept, remained stable even in the oldest subjects. The concepts of intermediate difficulty (i.e., substance and weight conservation) were present in only about half the oldest group. The formal operation of volume conservation, regarded as the latest developing and most complex acquisition had virtually disappeared from the response repertoire of the oldest subjects.

Riegel and Riegel's (1971) discussion of the age decrements frequently noted in cross-sectional research bears on the present results. They regard age decrement as a manifestation of the increasing number of subjects exhibiting a sudden drop in test performance within five years prior to death ("terminal drop"). As noted earlier, disintegration of logical operations abilities is thought to be an indication of neural decrement and, perhaps, impending death (Hooper, Fitzgerald, & Papalia, 1971). Although a systematic record of the survival status of conservers versus non-conservers was not maintained, the death of one 72-year-old non-conserver

was noted within two months after testing. This anecdotal information may be regarded as tentative support for the hypothesis that state of neurological decrement is being reflected in non-conservation responses. Formal information attained through longitudinal analyses of large numbers of older subjects is now regarded as the integral next step in determining the extent and implication of logical thought development across the life-span.

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Footnotes

1. This paper was presented at the annual meeting of the Eastern Psychological Association, April 27-29, 1972, New York, N.Y. It is based upon a dissertation submitted to the Graduate School, West Virginia University, Morgantown, West Virginia in partial fulfillment of the requirements for the degree of Doctor of Philosophy. The author wishes to acknowledge the assistance of her Chairman, Hayne W. Reese and D. Dwight Harshbarger, Ruth P. Hughes, Charles E. Kenoyer, Stephen W. Porges, and Neil R. Snyder in the completion of this study. Frank H. Hooper is also acknowledged for his assistance in the preparation of this manuscript.

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Table I

Percentage of subjects passing each task at each age level

Ages	Tasks			
	Number	Substance	Weight	Volume
6 - 7 years	75%	56%	37.5%	6.25%
11-13 years	100%	68.7%	50%	12.5%
18-19 years	100%	100%	100%	50%
30-54 years	100%	87.5%	81.5%	37.5%
55-64 years	100%	100%	93.7%	75%
over 65 years	100%	62.5%	50%	6.25%

Age Differences in Task Performance

Age Comparisons	Tasks: Number	Substance	Weight	Volume
6-7/11-13	$x^2 = 7.14$ $p < .01$*	$x^2 = 1.20$ $p > .20^x$	$x^2 = 1.14$ $p > .30^x$	$x^2 = .25$ $p > .50^x$
6-7/18-19	$x^2 = 7.14$ $p < .01$*	$x^2 = 11.73$ $p < .001$*	$x^2 = 17.60$ $p < .001$*	$x^2 = 7.12$ $p < .01$*
6-7/30-54	$x^2 = 7.14$ $p < .01$*	$x^2 = 5.66$ $p < .02$*	$x^2 = 8.29$ $p < .01$*	$x^2 = 4.17$ $p < .05$*
6-7/55-64	$x^2 = 7.14$ $p < .01$*	$x^2 = 11.73$ $p < .001$*	$x^2 = 13.85$ $p < .001$*	$x^2 = 18.18$ $p < .001$*
6-7/over 65	$x^2 = 7.14$ $p < .01$*	$x^2 = .52$ $p > .30^x$	$x^2 = .65$ $p > .30^x$	$x^2 = 0.0$ $p > .99^x$
11-13/18-19	$x^2 = 0.0$ $p > .99^x$	$x^2 = 8.13$ $p < .01$*	$x^2 = 13.50$ $p < .001$*	$x^2 = 7.12$ $p < .01$*
11-13/30-54	$x^2 = 0.0$ $p > .99^x$	$x^2 = .73$ $p > .30^x$	$x^2 = 4.98$ $p < .05$*	$x^2 = 1.50$ $p > .20^x$
11-13/55-64	$x^2 = 0.0$ $p > .99^x$	$x^2 = 8.67$ $p < .01$*	$x^2 = 9.89$ $p < .01$*	$x^2 = 10.28$ $p < .01$*
11-13/over 65	$x^2 = 0.0$ $p > .99^x$	$x^2 = .55$ $p > .30^x$	$x^2 = .12$ $p > .70^x$	$x^2 = 0.0$ $p > .99^x$
18-19/30-54	$x^2 = 0.0$ $p > .99^x$	$x^2 = .53$ $p > .30^x$	$x^2 = 1.65$ $p > .10^x$	$x^2 = .13$ $p > .70^x$
18-19/55-64	$x^2 = 0.0$ $p > .99^x$	$x^2 = 0.0$ $p > .99^x$	$x^2 = 0.0$ $p > .99^x$	$x^2 = 4.81$ $p < .05$*
18-19/over 65	$x^2 = 0.0$ $p > .99^x$	$x^2 = 5.13$ $p < .05$†	$x^2 = 8.17$ $p < .01$†	$x^2 = 5.57$ $p < .02$†
30-54/55-64	$x^2 = 0.0$ $p > .99^x$	$x^2 = .53$ $p > .30^x$	$x^2 = .70$ $p > .30^x$	$x^2 = 11.11$ $p < .001$*
30-54/over 65	$x^2 = 0.0$ $p > .99^x$	$x^2 = 1.50$ $p > .20^x$	$x^2 = 2.21$ $p > .10^x$	$x^2 = 2.29$ $p > .10^x$
55-64/over 65	$x^2 = 0.0$ $p > .99^x$	$x^2 = 5.13$ $p < .05$†	$x^2 = 8.17$ $p < .01$†	$x^2 = 11.38$ $p < .001$†

x = no significant difference

* = older group superior

† = younger group superior